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THE RELATIONSHIP BETWEEN SELECTED NON-AUDITORY MEASURES AND THE HEARING THRESHOLD LEVELS OF AN AVIATION NOISE-EXPOSED POPULATION

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PENSACOLA FLORIDA

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SUMMARY PAGE

THE PROBLEM

Permanent hearing loss resulting from noise exposure remains a problem in the military environment. Determining beforehand whether a specific person is likely to sustain a noise-induced hearing loss has been the goal of researchers ever since it was first learned that not all individuals are equally affected by noise. The most popular approach to the problem has involved psychoacoustic testing of one form or other, but a more recent mode of inquiry has involved the identification of non-auditory correlates of noise-induced hearing loss. The identification of such non-auditory variables would contribute positively to the ultimate development of a multivariate test of noise susceptibility.

FINDINGS

In a retrospective analysis of data collected during the 1963 follow-up of the NAMRL Thousand Aviator Study, two hearing level groups were identified (normal and impaired) and compared along 33 non-auditory dimensions. It was discovered that these two equally noise-exposed groups could be differentiated according to their smoking history and eye color. That is, the impaired hearing group reported smoking more cigarettes for a greater period of time than did the members of the normal hearing group. Furthermore, blue-eyed individuals were over-represented in the impaired hearing group and under-represented in the normal hearing group, whereas the reverse was the case for brown-eyed aviators. These relationships are among the first to be reported using permanent threshold levels and a noise-exposed population. It is recommended that further research be undertaken to verify the preceding findings and identify additional non-auditory correlates of noise-induced hearing loss.

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INTRODUCTION

Permanent hearing loss sustained as the result of noise exposure continues to be a problem in both industrial and military environments. In fact, recent research conducted here at the Naval Aerospace Medical Research Laboratory (NAMRL) indicates that, among Navy enlisted personnel, the prevalence of hearing loss is greater than was initially thought (1). The fact, however, that not all individuals experience a loss of hearing to the same degree or at the same rate (e.g., 2,3), suggests that individual factors bear some importance in a person's response to noise exposure.

Because of the obvious value of a valid, reliable, and easy-to-administer test of individual noise susceptibility, much research effort has been expended over the years in the search for variables predictive of individual susceptibility to noise-induced hearing loss. To date, most of this research has centered around paradigms involving tests of some form of auditory capability. The present investigation was undertaken in an attempt to identify possible non-auditory correlates of noise-induced hearing loss.

BACKGROUND

Research in the area of human susceptibility to noise-induced hearing loss has always been faced with a dilemma--without an available test of noise susceptibility, the only way of positively determining that an individual is susceptible to sustaining a noise-induced permanent threshold shift (NIPTS) is by the fact that he presently <u>has</u> a NIPTS. And measures derived for purposes of prediction from his now aberrant system bear questionable relevance to normal, yet-to-be-noise-damaged systems. A potentially promising solution to this dilemma is based on the logical assumption that those ears most susceptible to <u>temporary</u> threshold shifts (TTS) would also be those ears most susceptible to permanent shifts in threshold (PTS). Research employing temporary fatigue techniques has, over the years, revealed that there can be right ear/left ear differences (4), that the nature of the TTS experienced is dependent on the characteristics of the fatiguing stimulus (5), and that the susceptibility to a given fatiguing stimulus might be time-varying, as revealed by relatively low test-retest reliability measures (3). Given these findings, it is not too surprising that a general test of noise susceptibility has yet to be developed. Even the validity of the assumption underlying the TTS technique (i.e., that TTS mirrors PTS susceptibility) has not been unanimously accepted (6). It is also possible that, even if a test based on this assumption were to be developed, time constraints as well as a reluctance to induce even a temporary shift in threshold would render the test unacceptable to some.

As noted earlier, the most popular approaches to the noise susceptibility question have historically involved experimental manipulations of variables directly affecting the auditory system. Besides the TTS design, research has been conducted, and is continuing, with paradigms involving threshold octave masking (7,8), aural overload (9,10), acoustic reflex (11), perception of degraded speech (12), and so on. A somewhat more recent approach to the problem has involved the correlation of non-auditory variables with measures of threshold shift.

One of the principal questions the present study sought to investigate concerned the reported finding that susceptibility to auditory fatigue is correlated with the eye color of the subject. The hypothesis that the pigment (melanin) present in the stria vascularis of the inner ear serves an angio-protective function and that the degree of pigmentation of the stria is mirrored by the amount of melanin present in the iris was first posited by Bonaccorsi (13). Subsequent research by Tota and Bocci (14) and Hood, Poole, and Freedman (15) supported Bonaccorsi's contention by presenting results which showed that the noise-induced TTS experienced by blue-eyed (i.e., low melanin) subjects was more severe than that experienced by brown-eyed (high melanin) subjects. The Hood et al. study also went on to cogently explain earlier discordant results obtained by Karlovitch (16) on the basis of differences in methodology. This body of findings combined with ancillary evidence such as the apparent correlation between hereditary deafness and pigmentation disorders (17), hearing loss and albinism (18), and the lower incidence of NIPTS among females (19) (who, as a group, have more darkly pigmented irises (20)), suggested that a closer look at the eye color variable in terms of NIPTS susceptibility appeared warranted. Since the initiation of the present study, results obtained by Carter (21) from an examination of the threshold levels of apprentices attending trade school courses revealed a statistically significant difference between "only melanin" and "no melanin" ears at the 4000 Hz measurement point, with the "no melanin" group having the worse hearing. Whether this effect would have been more apparent had older, more noise-exposed subjects been used is unknown.

Another group of non-auditory variables which have been shown to have some bearing on hearing loss involves the cardiovascular system. Rosen and his colleagues have published several articles (22-26) noting the relationship between hearing loss and such measures as elevated cholesterol levels, hypertension, atherosclerosis, and coronary heart disease. Similarly, Cunningham and Goetzinger (27) found modest but significant hearing threshold differences at 14000 Hz between subjects with normal lipid levels and those with hyperlipidemia. Ismail, Corrigan, MacLeod, Anderson, Kasten, and Elliot (28) published results showing an increased ability to recover from noise-induced TTS among those subjects who had improved their cardiovascular functioning through physical exercise. And Willson, Chung, Gannon, Roberts, and Mason (29), addressing the same general question, found that an elevated serum cholesterol level was the only index of general health and well-being which appeared to be related to noise-induced hearing loss, although the presence of cardiovascular risk factors approached significance. On the other hand, Drettner, Hedstrand, Klockhoff, and Svedberg (30) found no significant correlations between the hearing threshold levels of high versus low cardiovascular risk populations of 50 year-old Swedish men.

Given the preceding state of the literature regarding cardiovascular condition and hearing threshold levels, it was believed that it would be beneficial to examine this class of variables in the present study.

In addition, because hearing loss (not necessarily noise-induced) has been correlated with social class (30,31), and because external auditory canal volume has been mentioned as a possible correlate of susceptibility to noise-induced threshold shifts (32), a social index measure and somatotypings were also included in the present analyses.

PROCEDURE

Retrospective analyses were performed on data gathered during the 1963 follow-up of members of the U.S. Navy's Thousand Aviator Study. The Thousand Aviator Study was begun in Pensacola, Florida in 1940 as a survey to validate techniques for preselecting pilot trainees, but took on a longitudinal character when medical follow-up examinations of the population were instituted in 1951, and were continued in 1957, 1963, 1969, and 1976. Included in the follow-up battery was a standard, air conduction, self-recorded audiogram which provided us the opportunity to examine hearing threshold levels in conjunction with numerous non-auditory variables.

Although the initial contingent of Thousand Aviators totaled 1056, only 675 were able to be tested during the 1963 follow-up. The audiograms of these 675 individuals were examined and two dichotomous groups were identified: "normal hearing" and "impaired hearing." Normal hearing individuals were defined as those who exhibited hearing threshold levels below 25 dB for both ears at all of the following frequencies: 500, 1000, 2000, 3000, 4000, and 6000 Hz. Impaired hearing subjects were defined as being individuals having hearing threshold levels greater than 50 dB at any of the following frequencies: 3000, 4000, or 6000 Hz. A total of 97 persons were categorized as having normal hearing, whereas 104 persons were classified as having impaired hearing. The two groups were then univariately compared along several non-auditory dimensions including:

- eye color
- smoking history
- blood pressure (systolic and diastolic; basal and casual; sitting and supine)
- heart rate
- serum cholesterol
- serum triglycerides
- serum lipoproteins
- serum uric acid
- atherogenic index
- presence of arcus senilis
- the ten scales of the Guilford-Zimmerman Temperament Survey
  - emotional stability
  - restraint
  - general activity
  - seriousness
  - objectivity
  - social ascendancy
  - friendliness
  - thoughtfulness
  - personal relations
  - masculinity
- social index
- alcohol consumption
- somatotype

(See Appendix A for a description of the procedures employed to derive these measures.) In those instances where interval data were available, the Student t-test was the chosen test of statistical significance. Nominal data (e.g., eye color, arcus senilus) were analyzed using the Chi-square technique.

Regarding noise histories, a precise description of the noise exposure of individual subjects was not possible from the available data. However, it is instructive to note that at the time the 1963 data were gathered, 85 percent of the participants in the study had been exposed to a minimum of five years of aviation noise (either as pilots or members of flight crews), with the mean exposure being 14.4 years.

RESULTS

The two variables which successfully differentiated the two audiometrically dichotomous groups are shown in Table I. It can be seen that those individuals who had exhibited normal hearing at the time of the 1963 examination had lower smoking indices than those with impaired hearing. An analysis of the relative representation of non-smokers in the two hearing groups was attempted but was unsuccessful for the reason that an insufficient number of these aviators had never smoked. Regarding the eye color variable, it can be seen from Table I that blue-eyed persons were over-represented in the impaired hearing group and under-represented in the normal hearing group whereas the reverse was the case for the brown-eyed subjects. A Chi-square analysis revealed that these cell frequencies differed sufficiently from expected values to be statistically significant at the 95 percent confidence level. This deviation (in percent) from expected frequencies is displayed graphically in Figure 1.

Table I

Variables Which Successfully Differentiated the Two Audiometrically Dichotomous Groups

SMOKING INDEX (Number of Packs per Day X Years Smoked)				
	Mean	SD		
Normal Hearing	25.8	(18.2)	$t=2.41$	$p < .05$
Impaired Hearing	32.8	(18.3)		
EYE COLOR	Blue	Brown		
Normal Hearing	48	41	$X^2=4.45$	$p < .05$
Impaired Hearing	63	28		

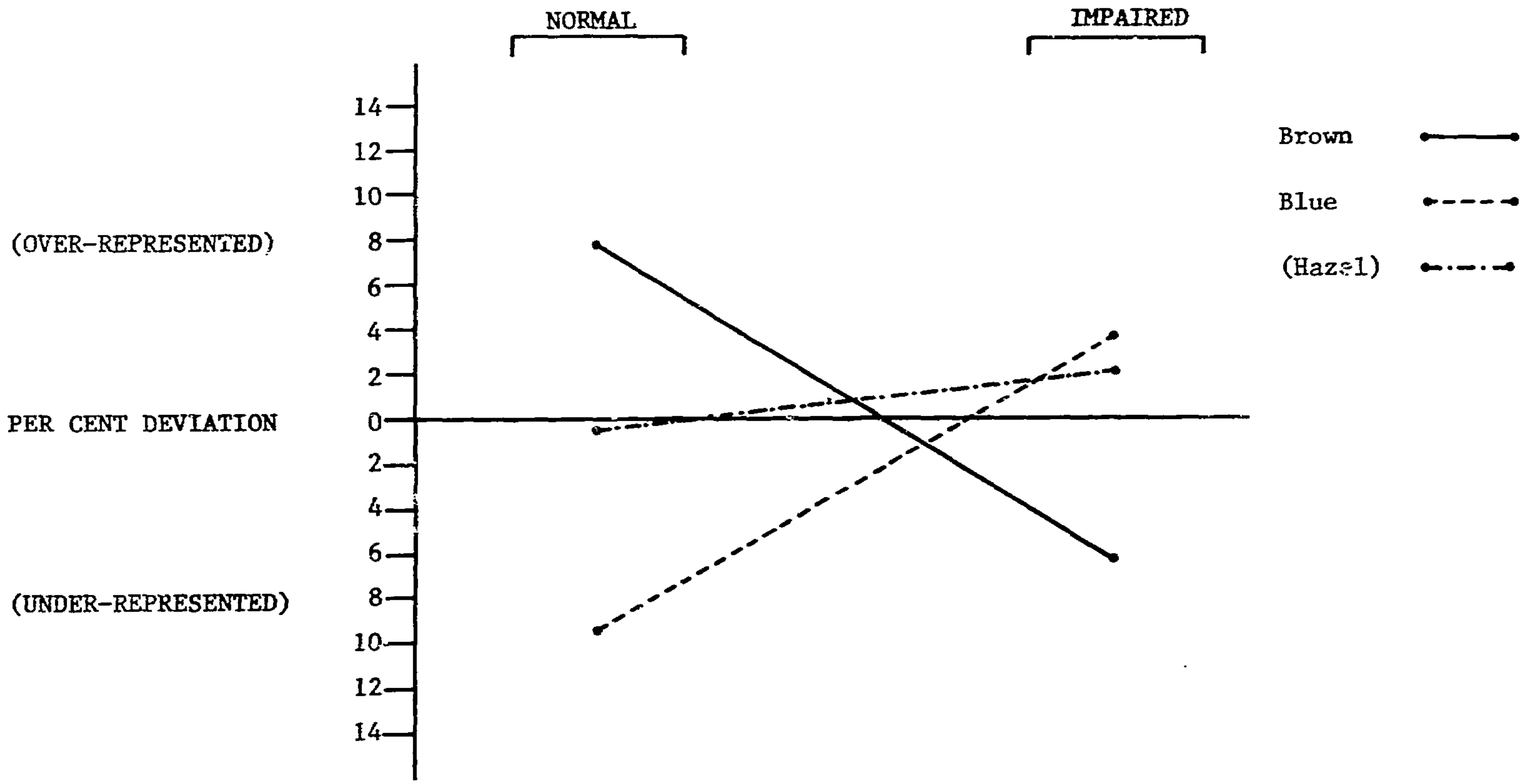

Figure 1

Deviation (in percent) of eye color groups from expected frequencies of representation in the two hearing level groups. (Hazel eye color data included for comparison.)

As a note of interest and as a check on the eye color variable, the data were re-examined and the incidence of "hazel-eyed" (presumed to be a medium melanin content category) in the normal hearing and in the impaired hearing groups was determined and included in Figure 1. It can be seen that this group falls between the extremes delineated by the blue-eyed/brown-eyed groups and does not appear to differ significantly from expected values, although it must be noted that the incidence of this eye color was very low (6.2 percent of the Thousand Aviator population) and no statistical analyses were attempted.

Table II contains the relevant data for those variables which failed to appear differentially in the two hearing groups.

Table II

Variables Which Did Not Successfully Differentiate the Two Audiometrically Dichotomous Groups

	M	SD	Significance
AGE IN YEARS (In 1963)			
Normal Hearing	46.7	(2.4)	ns
Impaired Hearing	46.8	(2.5)	
YEARS FLYING			
Normal Hearing	14.4	(8.6)	ns
Impaired Hearing	14.4	(8.6)	
TOTAL FLIGHT TIME (Hours per year, last five years)			
Normal Hearing	52.9	(43.0)	ns
Impaired Hearing	41.3	(24.8)	
BLOOD PRESSURE--Systolic (supine; basal)			
Normal Hearing	128.9	(15.1)	ns
Impaired Hearing	128.5	(15.1)	
BLOOD PRESSURE--Diastolic (supine; basal)			
Normal Hearing	79.5	(9.4)	ns
Impaired Hearing	81.0	(11.3)	
BLOOD PRESSURE--Systolic (sitting; basal)			
Normal Hearing	124.2	(13.3)	ns
Impaired Hearing	125.6	(16.0)	
BLOOD PRESSURE--Diastolic (sitting; basal)			
Normal Hearing	84.0	(9.5)	ns
Impaired Hearing	85.6	(11.8)	

TABLE II (cont'd)

	M	SD	Significance
BLOOD PRESSURE--Systolic (supine; casual)			
Normal Hearing	125.0	(12.1)	ns
Impaired Hearing	125.1	(14.6)	
BLOOD PRESSURE--Diastolic (supine; casual)			
Normal Hearing	77.5	(8.6)	ns
Impaired Hearing	79.5	(11.4)	
BLOOD PRESSURE--Systolic (sitting; casual)			
Normal Hearing	122.6	(13.3)	ns
Impaired Hearing	123.9	(15.7)	
BLOOD PRESSURE--Diastolic (sitting; casual)			
Normal Hearing	81.3	(9.1)	ns
Impaired Hearing	83.4	(13.0)	
HEART RATE			
Normal Hearing	73.6	(11.4)	ns
Impaired Hearing	73.3	(11.5)	
SERUM CHOLESTEROL (mg %)			
Normal Hearing	218.1	(46.9)	ns
Impaired Hearing	219.7	(43.7)	
SERUM TRIGLYCERIDES (mg %)			
Normal Hearing	189.9	(95.7)	ns
Impaired Hearing	194.7	(145.3)	
SERUM LIPOPROTEINS (mg %)			
Normal Hearing	408.8	(99.3)	ns
Impaired Hearing	413.5	(99.3)	
SERUM URIC ACID (mg %)			
Normal Hearing	6.1	(1.3)	ns
Impaired Hearing	5.9	(1.4)	
ATHEROGENIC INDEX (A weighted index of coronary heart disease; utilizes measures from two low-density lipoprotein subclasses)			
Normal Hearing	73.3	(24.3)	ns
Impaired Hearing	74.6	(31.3)	

TABLE II (cont'd)

	M	SD	Significance
PRESENCE OF ARCUS SENILIS (A visible fatty degeneration of the cornea; positively correlated with physiological age)			
Normal Hearing	16%		
Impaired Hearing	18%		
SOCIAL INDEX (A weighted index of occupation X income X education)			
Normal Hearing	29.9	(7.1)	ns
Impaired Hearing	30.2	(6.5)	
ALCOHOL CONSUMPTION ("3" = "1 or 2 drinks per week"; "4" = "1 drink per day")			
Normal Hearing	3.6	(1.3)	ns
Impaired Hearing	3.3	(1.4)	
SOMATOTYPE			
Normal Hearing	6.9	(1.9)	ns
Impaired Hearing	6.8	(2.0)	
GUILFORD-ZIMMERMAN TEMPERAMENT SURVEY (Ten Scales)			
E-Scale (Emotional Stability)			
Normal Hearing	21.0	(5.9)	ns
Impaired Hearing	20.3	(5.5)	
R-Scale (Restraint)			
Normal Hearing	19.1	(3.9)	ns
Impaired Hearing	19.1	(4.1)	
G-Scale (General Activity)			
Normal Hearing	17.5	(6.1)	ns
Impaired Hearing	17.0	(5.6)	
S-Scale (Seriousness)			
Normal Hearing	19.6	(5.6)	ns
Impaired Hearing	18.9	(5.8)	
O-Scale (Objectivity)			
Normal Hearing	20.7	(5.0)	ns
Impaired Hearing	19.8	(4.7)	
A-Scale (Social Ascendancy)			
Normal Hearing	17.3	(5.3)	ns
Impaired Hearing	17.6	(4.7)	

TABLE II (cont'd)

	M	SD	Significance
F-Scale (Friendliness)			
Normal Hearing	16.6	(5.3)	ns
Impaired Hearing	16.6	(5.4)	
T-Scale (Thoughtfulness)			
Normal Hearing	17.9	(4.6)	ns
Impaired Hearing	18.5	(4.4)	
P-Scale (Personal Relations)			
Normal Hearing	21.8	(4.5)	ns
Impaired Hearing	21.9	(4.1)	
M-Scale (Masculinity)			
Normal Hearing	21.9	(3.8)	ns
Impaired Hearing	21.2	(3.3)	

DISCUSSION

The finding that the impaired hearing group had a higher smoking index than did the normal hearing group was somewhat surprising if for no other reason than that very little research into the long-term effects of cigarette smoking on hearing threshold levels has been reported. There was the work of Zelman (33) which noted a greater incidence of presbyacusis among smokers than non-smokers as well as the finding of the Swedish research team of Drettner et al. (30) that there existed significant threshold differences at one frequency for one ear between smokers and non-smokers, but little else to directly link smoking behavior to hearing levels. Indirect indications that smoking behavior might be related to hearing threshold levels come, of course, from those studies reporting the association of hearing threshold levels and cardiovascular risk factors. A study published by Kuznetsov and Morozov (34), after the completion of the present investigation's data collection, noted a very large (and statistically significant) difference between the hearing thresholds of smokers and non-smokers. This Russian study also reported significant cardiovascular and respiratory differences among individuals suffering from neurosensory hearing impairment of various etiologies.

It is conceivable that since cigarette smoking lowers blood oxygen levels (e.g., 35) and raises blood carbon monoxide levels (36,37), the chronic occurrence of such a condition could result in a reduced auditory physiologic viability since low blood oxygen and high blood carbon monoxide levels have been shown to result in hearing loss (38,39). Other than the TTS studies, though, the present effort is the only one which has shown a smoking/hearing threshold effect for a noise-exposed population. The question of whether cigarette smoking actually increases the probability of incurring permanent hearing loss from noise exposure awaits further research, however. Also indicative of the need for additional research is the lack of apparent correlation in the present investigation between hearing threshold levels and reported correlates of cigarette smoking (e.g., heart rate (36); total serum cholesterol (40)). In fact, several correlates of smoking have been noted in the very population from which our two hearing groups were drawn (41).

The second variable which successfully differentiated between the normal hearing and impaired hearing groups was eye color. As noted earlier in this paper, this finding has been reported by investigators employing the TTS technique, but few analyses have been completed directly examining permanent noise-induced hearing loss in terms of eye color. Indirect support of the eye color hypothesis comes from surveys of noise-exposed populations known to differ in degrees of iris pigmentation. For example, Royster et al. (19) found that in an industrial noise-exposed population, those groups experiencing the least amount of hearing loss after an average of 11.4 years on the job were black females, followed by white females, black males, and white males (although the situation was somewhat complicated by frequency dependency effects). As a group, blacks tend to have more highly pigmented irises than whites (20), and females tend to have darker eyes than males (20), which generally predicts the rankings obtained by Royster et al. In non-experimental situations such as industrial surveys, however, direct, causative relationships are difficult to establish, and it is certainly possible that confounding variables (e.g., sociological) contributed to the results.

The eye color variable, nonetheless, continues to show a weak, but persistent, relationship with auditory threshold shift responsivities and may be useful in future multivariate analyses of the question of susceptibility to noise-induced hearing loss.

An examination of the results presented in Table II reveals that, because the two hearing level groups did not differ in mean age, number of years spent flying, and total flight time during the five years preceding the 1963 examination, the differences in their hearing levels were probably not due to differential exposure to aviation noise or differences in onset or rate of progression of presbyacusis. Other sociological and otological variables could conceivably account for the different hearing levels of the two groups, but data were not available to examine this possibility.

The negative results obtained for the remaining variables in Table II are also of interest. The fact that the two groups could not be differentiated along the dimension of cardiovascular condition does not necessarily imply that cardiovascular variables bear no relationship to the state of the physiology of the auditory system. Rather, it merely indicates that hearing loss is not correlated with cardiovascular indices to a sufficiently high degree that small differences among normal-range cardiovascular measures can be detected. That is, the studies which have reported the cardiovascular/hearing threshold relationship have generally dealt with normal versus "extreme" populations (e.g., normals versus those with hyperlipidemia (27), normals versus persons with very low lipid levels (23), etc.). The population of Thousand Aviators, on the other hand, represents a pre-selected, relatively homogeneous group of individuals who probably reflect an above average biological and psychological population in that they have enjoyed reduced morbidity and mortality rates relative to the general population (42). This reduced heterogeneity of variance might also explain, in part, some of the other negative results (e.g., somatotype, psychological traits) obtained in the present study. It also indicates the existence of a "matched group" situation for the comparison of any variables not among the pre-selected.

In summary, the present study has obtained results indicating that, among an aviation noise-exposed population, a group of individuals defined as having "normal" hearing threshold levels could be differentiated from another group of aviators with "impaired" hearing along the dimensions of cigarette smoking behavior and eye color. Although similar results have been obtained by other investigators, the cigarette smoking relationship is the first reported for a noise-exposed population and the eye color finding is among the first obtained utilizing <u>permanent</u> threshold levels. An additional 31 biomedical, psychological, and behavioral variables did not occur differentially in the two groups.

It is felt that continued research into the non-auditory correlates of noise-induced hearing loss could prove fruitful in the ultimate development of a multivariate test of noise susceptibility.

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APPENDIX A

Description of Variables

The following is taken directly from The Thousand Aviator Study: Distributions and Intercorrelations of Selected Variables by Albert Oberman, Norman E. Lane, Robert E. Mitchell, and Ashton Graybiel (43).

1. Age: Age in years at the time of subject's last birthday.

2. Years Flying: Number of years flown as a pilot or crew member, military or civilian aircraft.

3. Total Flight Time: Average number of hours flown per year as a pilot or crew member during the preceding five years.

4. Blood Pressure: Initial blood pressures were obtained after the fasting subject rested in a quiet room. Shortly thereafter the supine blood pressure was recorded from the right arm with a Bauman sphygmomanometer from which the back had been cut so that the column of mercury was visible from front and back. The examiner ascertained the systolic and fourth phase diastolic pressures viewing the mercury column from the unmarked side; at the appropriate time he signalled verbally to another observer who recorded the reading in mm Hg. The procedure was then repeated for the sitting blood pressures. In addition to the "basal" blood pressures, routine "casual" supine and sitting blood pressures were taken during the course of the physical examination.

5. Heart Rate: Resting heart rate (average lead I and lead V_6) during the fasting electrocardiogram.

6. Serum Cholesterol: Fasting value recorded in mg percent (according to method described in Abell, L., Levy, B., Brady, B., and Kendall, F., J. Biol. Chem., 195:357-366, 1952).

7. Serum Triglycerides: Triglycerides calculated in mg percent from lipoprotein fractions 0-12(X_1), 12-20(X_2), and 20-400(X_3) (described in Olsen, R. E. and Vester, J. W., Physiol. Rev., 40:677-733, 1960) according to the following:

$$\text{Calculated triglycerides (mg\%)} = 0.103X_1 + 0.258X_2 + 0.521X_3$$

8. Serum Lipoproteins: Lipoprotein subclass with flotation rates between S_f0 and S_f12 expressed in mg percent (according to deLalla, O. and Gofman, J., Methods of Biochemical Analysis. New York: Interscience Publishers, 1954).

9. Uric Acid: Fasting, recorded in mg percent (according to Brown, H., J. Biol. Chem., 158:601-608, 1945).

10. Atherogenic Index: This is a weighted value for coronary heart disease derived from two low-density lipoprotein subclasses, S_f 0-12 and S_f 12-400. The atherogenic index (formulated by Fogman, J., Strisower, B., deLalla, O., Templin, A., Jones, H., and Lindgren, F., Mod. Med., June 15, 119-140, 1953) is as follows:

$$A.I. = \frac{mg\%S_f\ 0\text{-}12 + 1.75\ (mg\%S_f\ 12\text{-}400)}{10}$$

11. Arcus Senilis: Presence or absence.

12. Social Index: Index of social status utilized was the "short" form of McGuire, C. and White, G. (Report No. 3, Austin, Texas: Univ. of Texas Dept. of Educational Psychology, 1955). Weights were assigned to occupation, source of income, and education, and weighted scores summed to obtain social status.

13. Alcohol Consumption: Consumption of alcohol was coded on a seven-point scale as (1) never drink, (2) rarely drink, (3) drink once or twice each week, (4) one drink per day, (5) two or three drinks per day, (6) more than three drinks per day, and (7) problem with alcohol.

14. Somatotype: Each subject was photographed and evaluated in the standard manner for somatotype by the anthroscopic method (Sheldon, W., Dupertins, C., and McDermoth, E., Atlas of Men. New York: Harper and Bros., 1954). Each of the three somatotypes was rated to the nearest half unit on a one to seven point scale.

15. Guilford-Zimmerman Temperament Survey: This is a paper and pencil personality questionnaire in which the subject answers 300 questions about himself with a yes, no, or ? reply. Scores are obtained on ten different scales (which are defined in Guilford, J., and Zimmerman, W., The Guilford-Zimmerman Temperament Survey. Manual of Instructions and Interpretations. Beverly Hills, Calif: Sheridan Supply Co., 1949).

16. Smoking Index: The number of years that a subject had smoked cigarettes times the number of packs of cigarettes smoked per day comprised the Smoking Index.

17. Eye Color: This measure was not objectively measured at the time of the examination but was rather based on the judgment of the attending examiner.

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18. SUPPLEMENTARY NOTES

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Hearing	Eye color	Noise susceptibility
Hearing conservation	Smoking	
Noise	Melanin	
Noise-induced hearing loss	Individual differences	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Individual differences in susceptibility to deleterious noise effects is one of the distinguishing characteristics of noise-related research. In an effort to identify and verify possible contributing variables to the susceptibility question, an examination of the relationship between the hearing threshold levels and selected anatomical, physiological, and behavioral measures of a noise-exposed population was undertaken.

Using data from NAMRL's Thousand Aviator Study, subjects categorized as

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) being of "normal hearing" (n=97) and of "impaired hearing" (n=104) were compared along several non-auditory dimensions. Results indicated that the two groups differed significantly ($p < .05$) in regard to smoking behavior and eye color. That is, the impaired hearing group had smoked more cigarettes for longer periods of time and tended to have more blue-eyed (i.e., low melanin concentration) individuals than did the normal hearing group. The latter finding is congruent with the speculation that melanin in the stria vascularis (the concentration of which is mirrored by iris pigmentation) serves to protect cochlear function.

• Variables which failed to differentiate the two hearing level groups included: blood pressure (systolic and diastolic; sitting and supine), heart rate, serum cholesterol, serum triglycerides, serum lipoproteins, serum uric acid, atherogenic index, presence of arcus senilis, the ten scales of the Guilford-Zimmerman Temperament Survey (emotional stability, restraint, general activity, seriousness, objectivity, social ascendancy, friendliness, thoughtfulness, personal relations, masculinity), social index, alcohol consumption, and somatotype.